

Stationary Equipment for Orchard Spraying and the Manufacture of Home-Made Liquid Lime-Sulfur

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STATIONARY EQUIPMENT FOR ORCHARD SPRAYING AND THE MANUFACTURE OF HOME-MADE LIQUID LIME-SULFUR

F. H. BALLOU

I. STATIONARY EQUIPMENT FOR ORCHARD SPRAYING

INTRODUCTION

The idea of experimenting with stationary equipment for orchard spraying first was conceived by the writer in the year 1905, but at that time was deemed impractical by horticulturists of the State. Twenty-four years later the subject of spraying orchards by means of centralized or stationary machinery was again brought to the forefront, and, because of interest, a modern, powerful stationary spraying unit was constructed at the Dale View Test Orchards in a hilly section of central Ohio in the autumn of 1929. This plant came far too late to be regarded as a pioneering project except in the State of Ohio, for in the meantime stationary spraying plants had been introduced and were in successful operation in orchards of the Pacific Coast.

Topographic conditions are such at the Dale View Orchards that spraying early was a real problem. The difficulties presented, however, are not confined to this particular orchard or locality; rather they are typical of a great area of the hilly sections of the State. Almost every form and size of spraying equipment had been used in this orchard, from hand-operated barrel outfits which soon became inadequate to portable power machines of several kinds. So steep were the hill slopes that driveways had to be graded between the tree rows at convenient intervals to permit the team-drawn sprayer to traverse the uneven ground safely. This, indeed, could be accomplished only by use of a relatively light, low-mounted spraying outfit of 100-gallon tank capacity, for uphill turns at the ends of the driveways rendered it impossible for a team of heavy horses to draw an outfit of greater weight and capacity up the very steep ascents. Downhill turns at the ends of the driveways were prohibited because of the extreme danger of the sprayer overturning.

Dusting the orchards by means of a modern power dusting machine was substituted experimentally for spraying for a period of 5 years. However, in spite of the fact that thorough dusting proved to give results fairly comparable with spraying, even the dusting machine was very difficult to handle. For, in dusting, each space between two tree rows necessarily had to be traversed in both directions at each separate application in order to cover both sides of each row of trees directly. It was possible only by exercising every possible care and precaution that the duster could be prevented from overturning. Only from the regular orchard driveways that formerly had been graded for use of the portable spraying machine could dusting be done with any considerable degree of safety.

Under the conditions described, the only really promising plan for spraying the orchards on those very steep hillslopes apparently was by installation of a stationary or centralized spraying plant with a pipe system fitted with properly spaced outlet valves and hose connections that would facilitate easy

and speedy coverage of all parts of the orchards. Such a plant now has been under successful operation for seven successive seasons—a period of sufficient length to prove or disprove the practicability of stationary spraying equipment under rugged, upland conditions in Ohio.

SIMPLICITY AND ADVANTAGES OF STATIONARY SPRAYING

The plan of stationary spraying is the simplest, unquestionably, of any so far devised and practiced for treatment of orchards. It eliminates use of wheeled trucks and teams or tractors during the entire spraying period, thereby preventing deep grooving or tearing by heavily burdened wheels of the smooth surfaces of orchard areas and consequent gulleying by rainfall and running water on sloping ground. It wholly obviates the loss of time in refilling tanks and mixing sprays when portable sprayers must be driven to and from the orchards or different sections of the orchards to more or less distant sources of water and spray materials. With capacious, divided tanks or two separate tanks, the work of spraying in the orchard is continuous throughout the regular half-day periods of operation; for, as the spray mixture is being drawn from one of the tanks, the companion tank is being filled with water and the proper materials added and thoroughly mixed. By means of a dual valve arrangement, shifting of the pump intake or suction from one tank to the other is almost instantaneous.

The stationary spray plant, moreover, insures that the expensive mechanical equipment at all times is securely sheltered from storm, wind, and sun, and that it is never subjected to the vibrations, strains, and shocks to which relatively lighter, less rigidly mounted team- or tractor-drawn outfits are subjected on rough and uneven ground. It enables the operator to have right at hand the necessary shop equipment, tools, and fittings for readjustments and repairs and likewise the materials and supplies for fully servicing the complete unit with the least possible waste of time.

DISADVANTAGES OF STATIONARY SPRAYING EQUIPMENT

Compared with its several distinct advantages, the disadvantages of stationary spraying equipment are relatively few. Certainly it is not adapted to experimental spraying in such projects as involve coverage of a considerable series of separate plots of trees with a like number of different spray formulas, for each change from one plot and formula to another requires that all spraying operations temporarily cease while the surplus spray mixture remaining in the spray tank and contained in the orchard pipe lines is drained into a waste pit or elsewhere. Moreover, not only are large quantities of costly spraying solutions thus wasted but also much time of the attendant of the plant and the several spraymen in the orchard.

As a matter of course, in use of a stationary spraying plant, all application of sprays must be from the ground. This requirement is considered objectionable by some owners whose easily traversed orchard land and portable outfits enable them to ride and do their spraying from tank platforms or towers. However, the fact should not be overlooked that on very steep ground use of portable spraying machines not only is extremely hazardous but application of the sprays from tank platforms or towers absolutely impossible. There are many upland orchards in Ohio in which use of portable sprayers necessitates practically all coverage to be done from the ground. Moreover, application of

sprays from the ground, if done by careful workmen, usually is more thorough than that accomplished by riding operators from seats, platforms, or towers on continuously moving spraying machines.

MODIFICATIONS OF THE STATIONARY PLAN OF SPRAYING

So versatile is the plan of stationary spraying that it can be adapted in whole or in part to a variety of conditions. By no means should reference to a stationary setup be suggestive only of a ponderous, heavy-duty assembly of expensive machinery suitable only for use in connection with extensive orchard areas. A fitting illustration of the practicability of small, inexpensive stationary spraying systems is the little outfits built for spraying in greenhouses. Equally practical and effective is the type of pony stationary spray plants for home grounds, vegetable and small-fruit gardens, and small orchards. Located in the basement of the home or in a spare corner of the garage or other outbuilding, such little spraying units service the farthest borders of the suburban or rural grounds.

Another modification of the stationary spraying plant readily and advantageously may be made at slight expense by certain owners of heavy, powerful portable spray outfits and generally level or gently rolling orchard ground. In connection with such orchard areas there are often cases in which there are sections occupying steep slopes of large ravines or valleys or the precipitous inclines of bordering hills or bluffs. Upon such slopes it is easily possible to install strategically placed pipe lines fitted with valve-controlled hose connections or "cutoffs". At the most conveniently accessible terminals of such emergency pipe installations the proper fittings are provided to facilitate quick connections with the discharge pipe of the portable spraying outfit. The latter, by this plan, is transformed into an efficient stationary plant. The one or more lines of spray hose, previously removed from their regular connections, are attached to outlet valves or cutoffs of the pipe line, as spraying proceeds throughout the piped section of the orchard. Thus, the more inaccessible areas of generally level orchards may be easily and quickly sprayed without traversing them with cumbersome, portable spraying outfits.

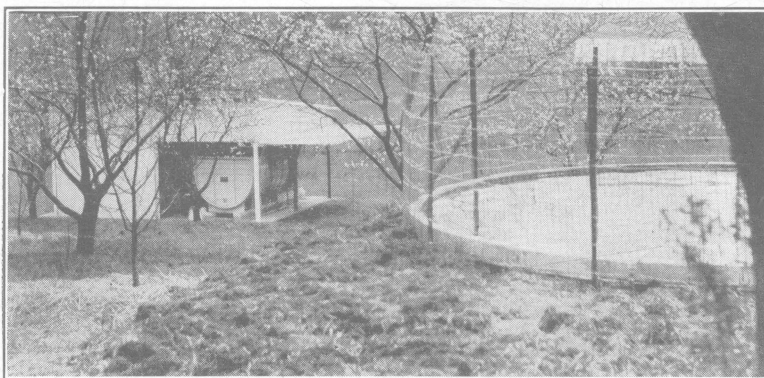
LOCATION OF THE STATIONARY PLANT

Second only in importance to the decision to establish stationary equipment for spraying is the question of its most convenient location. In most cases, it is safe to assume, the source of water supply should be the determining factor. It is highly desirable that the stationary spraying plant be a part of the homestead colony of buildings grouped near the source of water supply, whether such water flow from a natural spring or be pumped from wells by means of power equipment. In either case, if at all feasible the stationary spray plant should be located at a somewhat lower level to permit its spray tank or tanks to be filled rapidly, by gravity from a spring, water storage tank, cistern, or pond of generous capacity. A few hundred feet additional of conducting pipe, plus ample power and capacity of the spray pump, will satisfactorily deliver the spraying solution at surprisingly great distances and heights, leaving little reason for failure to locate the stationary spray plant at whatever point water is most readily available and the plant, as a whole, most conveniently serviced and otherwise cared for.

PLAN OF THE STATIONARY SPRAY PLANT AT DALE VIEW TEST ORCHARDS

THE WATER SUPPLY

Situated on the eastern slope of a very high ridge are the dwelling house and outbuildings of the Dale View Test Farm. A flowing spring is only 30 feet from the dwelling house. It is the outflow from this spring, supplemented by conservation of rainfall through a drainage system from roofs of the larger buildings of the group, that supplies water for spraying. Situated a few rods east and several feet below the level of the dwelling and spring is the cistern, which when first completed was of the open-top type. More recently a building of octagonal form has been erected over it. The circular wall of the cistern serves as a foundation for the building. The cistern occupies an earth excavation 6 feet in depth and 16 feet in diameter, its smooth rim extending about 6 inches above the ground level. The outlet pipe through which the water flows by gravity from the cistern to the stationary spray plant projects 2 inches above the heavy concrete floor of the cistern. A partial view of the cistern before being covered by the building is shown in Figure 1.



**Fig. 1.—Partial view of the open storage cistern for spray water,
before being covered by an octagonal building**
Stationary spray plant shown in background, at its
relatively lower level

Water is piped, underground, from the flowing spring to the cistern and is controlled by a valve in such a manner that it may be turned into the cistern or diverted to its natural course through a deep ravine which in recent years has been transformed into a rock garden. A second pipe of much larger size, also for the most part underground, brings to the cistern the roof drainage from the larger buildings including the dwelling. The water from this pipe system, likewise, may be turned into the cistern or taken on past it to the ravine simply by closing or opening the terminal of the conducting pipe at the latter named point.

In average seasons rainfall from the roof drainage, merely supplemented occasionally by water from the spring, provides an abundant supply of water for spraying the 20 acres of orchard. However, for the later or summer sprayings in seasons of unusually dry weather there is little or no water from rain-

fall, and the flowing spring gradually reduces its output to a mere trickle. In this emergency, by means of a third pipe system extending from the high-speed, high-pressure spray pump at the stationary plant to a large pond a few rods farther on at the foot of the slope and also connecting with the water storage cistern above described, the latter may be filled speedily with water for use in spraying.

HOUSING THE STATIONARY SPRAYING EQUIPMENT

A shelter, either previously available or especially constructed for the purpose, should be provided for the stationary spraying equipment, including the mixture tank. Plans for the one here described included a special, small, new building 16 x 20 feet in size divided crosswise by a partition into two compartments. The southern space of the building, 12 x 16 feet in size, was designed for the spraying outfit; the northern space, 8 x 16 feet in size, for a room for the orchard foreman.

The floor of both compartments is composed of a single slab of concrete 8 inches in thickness under the machinery compartment and 4 inches thick under the foreman's room. The floor throughout rests upon 16 inches of crushed stone imbedded in an earth excavation. The cross partition separating the two compartments stands upon a moulded sill of concrete 2 inches in height and 6 inches in width, which insures that no water or moisture from the machinery and mixing room can enter the foreman's quarters and likewise protects the base of the partition itself from dampness.

The machinery room is so arranged that it may be quickly thrown wide open at both ends and the south side (front) by pushing back the rolling doors at the ends and raising the two-section, corrugated steel doors hinged at the tops, which are held in a horizontal or slightly sloping position by sections of small steel pipe (Fig. 2).

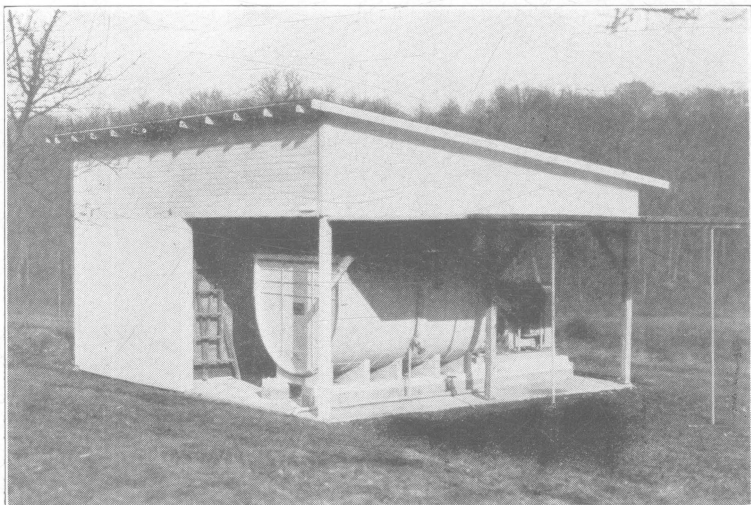


Fig. 2.—Structure housing the stationary spray plant, with all doors open for spraying operations

PLAN OF INSTALLATION OF THE SPRAYING EQUIPMENT

Lengthwise on the floor of the machinery compartment, as soon as the newly-poured cement floor had "set" sufficiently to work upon it, were moulded two parallel, heavy (6 x 6 inch) concrete sub-sills of the proper length and right distance apart to form the foundation for the motor, pump, and spray tank assembly. Heavy, square-head bolts ($\frac{1}{2}$ x 8 inches), spaced about 30 inches apart, were imbedded vertically, heads downward, in the sub-sills while the concrete composing them was still fresh and soft. The threaded ends of the bolts were left projecting from the smooth surface of the concrete a distance of $4\frac{1}{2}$ inches. After the concrete had thoroughly hardened, two wooden planks, each 2 x 6 inches in thickness and width and of the same length as the sub-sills, were securely fastened to the tops of each of the latter by means of the projecting bolts already mentioned. These wooden (pine) super-sills provide a more resilient and suitable base for the I-beam, steel frame upon which the motor and pump usually are already rigidly mounted as received from the factory, than does the concrete alone.

However, the concrete sub-sills serve a very useful purpose: They elevate to the height of 6 inches above the level of the cement floor and effectually protect from water and spray mixtures all wooden parts used in the proper mounting of the motor, pump, and tank unit as a whole. Construction of the foundation by use of concrete and plank, as above described, is quite clearly shown in Figure 3.

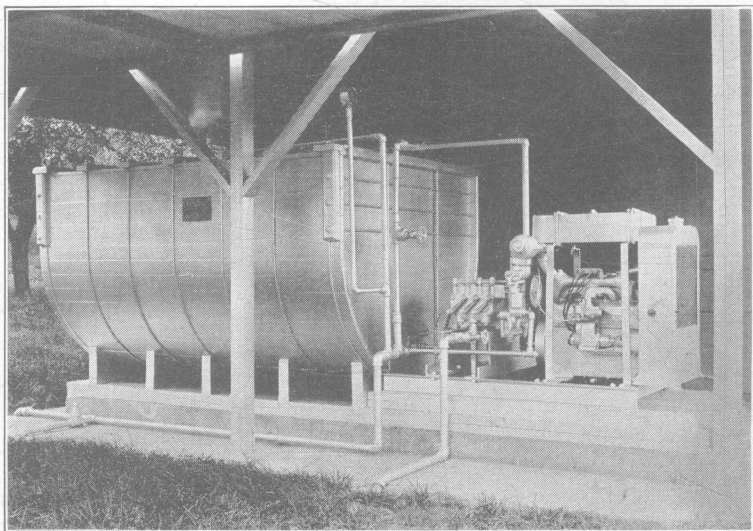


Fig. 3.—Complete assembly of the stationary spray plant showing concrete and timber base upon which motor, pump, and tank are mounted

An additional advantage of the parallel, concrete sub-sills moulded upon the cement floor is that when the spray tank has to be drained of its surplus contents by opening the large outlet fixture at the bottom, the released deluge of spray mixture cannot spread over the floor of the room but is confined and

guided by the water-tight sills toward a sink and underground drain just outside the building. If the waste sink should be at the motor end of the sills, a short block of concrete should be moulded crosswise at the tank end, between the terminals of the sills. By this arrangement it is not difficult to maintain a clean, dry floor in the machinery room.

Storage space for spraying materials and shelves for tools and supplies.—In the machinery compartment, against the previously mentioned partition, sufficient spare room for storage of a considerable bulk of spraying materials for immediate use is not only a great convenience but quite indispensable. To provide against damage to materials by water in case the spray tank accidentally be filled to overflowing, there is a platform of 1 x 12 inch boards supported by cross sections of 2 x 4 inch studding, cut the proper length.

Generous provision of shelves for tools, fittings, spare parts that are most likely to be needed, oil, grease, etc., by all means should be built-in features of the machinery compartment.

THE SPRAYING EQUIPMENT

The complete mechanical unit is composed of (1) a high-pressure spray pump of desirable capacity, (2) a motor (gasoline or electric) of ample power to operate the pump easily at its maximum working pressure, and (3) a mixture tank that will permit preparation of a generous quantity (500 gallons) of spray solution at a time.

Determination of the size or capacity of the spray pump should be based largely on the number of lines of hose desired to be used in spraying and, likewise, on the type and number of nozzles to be supplied by each hose. Even the size of the apertures or openings used in the disks of the individual spray guns has a direct bearing on the volume of spray solution that must be supplied under high pressure by the pump. Obviously, these details are largely matters for individual determination by orchard owners.

At the Dale View Test Orchards a power pump is used, the capacity of which is 20 gallons per minute at the pressure of 500 pounds. Invariably three lines of hose (requiring three spraymen) are used in the orchard. Under these conditions the 20-gallon-per-minute pump set at 500 pounds pressure at the spray plant is very satisfactory, yielding ample pressure for the three lines of hose even on the high hilltops a quarter of a mile distant and maintaining a satisfactory overflow of solution through the pressure relief valve back into the spray tank.

The gasoline motor used in the Dale View setup is a four-cylinder, roller-bearing type rated at 15 horse power. It possesses abundant energy to operate a pump of considerably greater capacity than the one at present in use.

There are various types of power spray pumps and motors turned out by different manufacturers that doubtless would prove excellent for the stationary spraying plant. The prohibitive cost prevents a comparative trial of the different power units.

The spray tank is another important feature of stationary equipment. The one in use at Dale View has a capacity of 1000 gallons. However, it is divided by a cross partition into two equal, or 500-gallon, compartments. Such division, supplemented by proper arrangement of the service pipe and valves, permits spraying from one tank compartment while the other is being filled and the mixture prepared. When nearly all of the spray solution has been pumped from tank No. 1, its outlet valve is closed and the outlet valve of tank No. 2 opened. Pumping from No. 2 begins without an instant's delay.

A heavy, power-driven, steel agitator shaft fitted with propeller-type mixing blades extends through both tank compartments.

Each of the two tank compartments, obviously, has its own filling door on the large top or platform of the tank unit, through which the water is turned in under natural or gravity pressure and the spray materials added.

An additional important arrangement intimately related to the dual spray tanks is that the overflow pipe leading from the pressure relief valve of the pump to the spray tanks should be divided by a "Y" into two separate overflow lines of different lengths, each fitted with a gate valve and downward turning elbow where the terminals reach the filling doors of the double tank. For the overflow of surplus spray solution must be returned to the tank compartment from which the mixture is being pumped. If the overflow were permitted to be discharged into the tank that is being refilled with water, a solution of unknown but considerably greater strength than the formula desired naturally would be the result. One of the two valves at the terminals of the overflow pipes must always be open. This is of extreme importance.

Water for spraying is delivered into either of the two tank compartments through the filling doors at the top, by means of a horizontal, swinging elbow extending from the vertical water standpipe rising from beneath the concrete floor close beside the spray tank. The water comes from the large storage cistern farther up the hill slope under natural or gravity pressure. The vertical water supply pipe also is fitted with a standard hose bib to which a section of $\frac{3}{4}$ -inch hose 15 to 20 feet in length may be attached.

Figure 4 presents a partial view of the spray tank, the water standpipe, the pump supply pipe (near the floor), and the two gate valves by which pumping is shifted from one tank compartment to the other.

A large (10 x 48 inch), cylindrical, seamless steel air chamber is mounted on top of the spray tank and connected by piping with the spray discharge pipe that leads to the orchards. The air chamber is only dimly seen in the more heavily shaded portion of the photograph in Figure 3. As pressure is built up after the motor and pump have been set in motion the spray solution is forced up into the lower part of the vertical air chamber. As the level of the spray solution continues to rise in the airtight chamber, the air in the upper part of the latter becomes more and more compressed, with the result that an extremely resilient volume of air is formed. This "cushion" of compressed air not only produces very uniform pressure for spraying in the orchard but serves as a very sensitive and effective shock absorber in protection of the motor and pump from the abrupt variations in pressure which very frequently occur when one, two, or all of the spray guns in the orchard are suddenly shut off.

The air pressure gauge is mounted at the terminal of a vertical pipe branching from that which leads to the air chamber and is an indispensable instrument in connection with a power spraying outfit of any type.

All valves used in connection with a stationary spray plant and orchard pipe system should be of the gate type and very best quality obtainable. Such valves as are guaranteed to withstand extremely high pressures are quite expensive, but low grade ones that simply will not do so, except possibly for a brief period, are even more expensive in the long run.

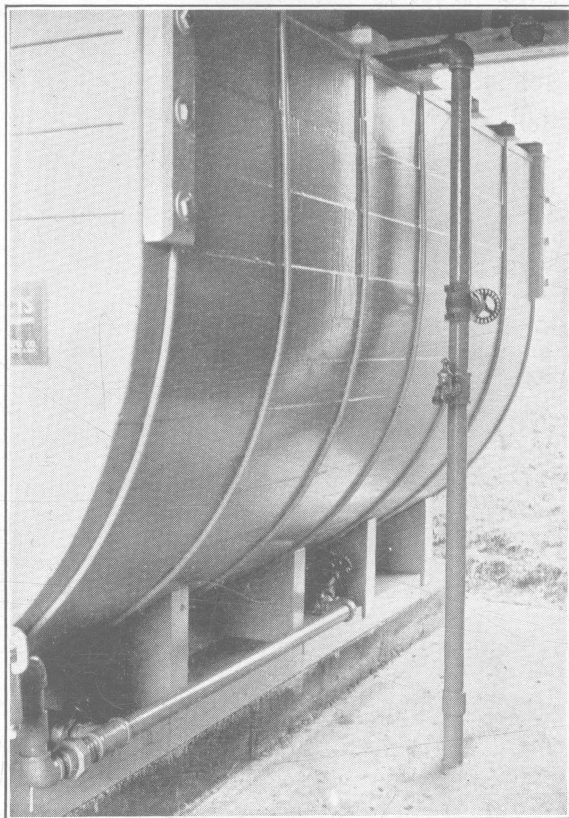


Fig. 4.—Close-up view of 1000-gallon spray tank, vertical water standpipe with swinging elbow at top for filling the two tank compartments, and, at bottom, the pipe through which the spray solution is conducted from the tanks to the power pump.

THE ORCHARD PIPE SYSTEM

In the Dale View stationary spraying project a good grade of galvanized steel water pipe has been in use for 6 years with no indication of serious deterioration thus far apparent.

The main pipe line leading from the stationary spray plant through the orchard (approximately 2000 feet) is $1\frac{1}{4}$ inches in diameter. The lateral pipe lines extending from the main or "trunk" line are $\frac{3}{4}$ inch in diameter.

The lateral or service lines are laid five tree rows, or about 175 to 200 feet, apart. In other words where the tree rows are spaced either 35 or 40 feet apart, the service pipe lines lie beneath the middle rows of five-row sections or blocks of trees.

Hose connections of the quickly attachable and detachable type are fitted into the side openings of "T" pipe couplings at convenient intervals—about every fifth or sixth joint of pipe, which would be approximately 100 to 120 feet apart. By use of 100-foot lengths of spray hose, the spraymen thus may be enabled to reach quite readily and with hose footage in reserve all of the trees in a 15- or 20-tree block even to the farthest corners from each hose coupling.

On hilly or rolling orchard ground where the grass-mulch method of culture is employed, it doubtless is preferable to lay the spray pipe system on the surface of the ground close to the bases of the trees.

Where the orchard pipe lines cross orchard driveways, they either may be slightly lowered by shallow trenching and covering with soil or covered rather securely without trenching. The dangers to be avoided in such crossings are two-fold: First, that of breakage of the pipe line by passage over it of heavily laden wagons or trucks; second, the possible formation of "pockets" by trenching and lowering the pipe lines, from which spray mixture or water may not be perfectly drained when freezing weather approaches.

Moreover, in general, where the orchard pipe lines are laid on the surface of hilly, rolling, or uneven ground, provision must be made for perfect drainage of such lines at each and every low point. This may be done readily either by use of T couplings fitted with threaded, removable plugs or of standard pipe unions that can be easily and quickly separated when cold weather threatens. However, at the time of removal of the drainage plugs or disjoining of the pipes at the threaded unions, it is a good plan to insert in each pipe opening thus resulting a small plug formed of fine copper or galvanized wire netting such as is used for screen doors. Such plugs permit free drainage of water from the pipes and at the same time prevent explorations within by field mice.

In cases where it is desired to install spray pipe systems wholly underground so that they may not be hindrances to the regular practice of tillage and cultivation of the orchards, there are two important points to be considered: First, if the orchard areas are so nearly level that the pipe systems cannot be readily and completely drained by the gravity process, they either must be buried at sufficient depth in the ground to prevent freezing of the water they contain or else pumped full of crude oil or some dependable and harmless anti-freeze solution. Thorough flushing of the lines with clear water at the coming of the next spraying season will, of course, be necessary—the oil or anti-freeze solution being blown out of the various pipe terminals into receptacles and saved or upon the ground and wasted as owners may prefer.

Second, where orchard areas are slightly rolling, where tillage and cultivation comprise the plan of culture, and where shallow burial and thorough drainage offer a promising possibility in comparison with the alternative of sinking the pipes below the frost line, no effort should be spared to determine by surveyors' instruments or the proper use of a common spirit level the proper locations for safe drainage terminals.

CARE OF THE ORCHARD PIPE SYSTEM

A question that is asked more frequently than any other is: "Do the pipes have a tendency to become filled and clogged with residue from the spray mixtures?" The answer is that during 7 years' use of the same pipe system at the Dale View Test Orchards, there has not been a single case of such accumulation or stoppage; and there is no present evidence that such a condition is imminent.

There are two important precautionary measures to be employed with a view to maintaining the orchard pipe system in good condition, as follows: First, thoroughly to flush and cleanse the entire system immediately following the application of each successive spray of the season, by pumping clear water through the system. The procedure, in short, is as follows: Fill one of the tanks of the spray outfit with fresh water. Start the motor and pump. Under full spraying pressure the valve at each terminal of the pipe line system is, in turn, thrown wide open and the contents of spraying solution blown out. In a short time clear water will begin to issue from the terminal. After a moment's delay the attendant closes the valve and passes on to the next terminal, repeating the process, until clear water has displaced the spraying solution throughout the entire pipe system.

In warm weather the pipe lines are permitted to remain full of clear water during the periods between sprayings. However, in very early spring, if freezing temperature threatens, it is well to drain the lines thoroughly. Surface pipe systems, as before indicated, should be perfectly drained for the entire late autumn and winter seasons.

The second precautionary measure to insure clean pipe systems with which to begin spraying is simple but worthy of mention: As soon as all drainage openings of the line have been closed and the entire system fully intact, it is well to traverse the entire layout at a brisk pace, sharply striking the pipes at every step by use of a medium weight hammer. This results in the loosening of any possible interior incrustations or scales either of metal or spray residue. The spray motor and pump are then started under full spraying pressure, the pipe terminals opened in turn, and a generous quantity of clear water forced through the lines, thus removing whatever sediment may have been loosened by the hammer strokes. During this operation, obviously, the entire pipe system is subjected to a desirable preliminary test before the season's spraying has begun, and any possible leakage is discovered and remedied. Close observation of the pressure gauge at the spray plant will quickly determine the important question of leakage even if it be ever so slight.

STARTING THE STATIONARY SPRAYING MACHINE

So far as the writer is aware no definite instructions ever have been issued in print by manufacturers or others that are of real assistance to those who have had no experience with stationary spraying machinery. The assembly, as a whole, is a rather confusing as well as imposing array of pipes, valves, and "gadgets" of various descriptions. Brief instructions that are generally applicable to such units, regardless of the particular type or "make" of the outfit, may prove helpful and are given below.

In preparation for spraying, spray tank No. 1, first of all, should be filled with water.

The required quantities of spray materials for a tank of spray solution next should be weighed or measured out and placed on top of the tank in readiness for adding to the water as soon as the machinery is in operation and in proper adjustment.

After placing the spraying materials in readiness for use, see that the valve at the terminal of the overflow pipe leading from the pressure regulator is open, in order that the surplus spray solution may return to the tank from which it is pumped.

Open the outlet valve near the bottom of tank No. 1 to permit flow of its contents into and through the intake or suction pipe of the pump. Make sure that the corresponding outlet valve near the bottom of tank No. 2 is closed.

Close the valve in the large main or orchard pipe line. (This valve is located just outside of the foundation of the building in which the spray plant is housed.)

Also close the valve that is installed in the pipe that connects the pressure regulator or pump overflow pipe with that of the main line that goes to the orchard. (This valve is shown in Figure 3 near the center of the front end of the spray tank.)

The outfit is now ready for the motor to be started. The pump is so situated below the level of the water or solution in the spray tank that it is self-priming. With the motor in action, pumping and vigorous agitation of the contents of tank No. 1 begin immediately and pressure will quickly build up in the air compression chamber to the point that the pressure regulator will release and discharge the entire volume of water passing through the pump, sending it through the overflow pipe back into the tank from which it came.

While the pressure is developing as above described, the clock-like pressure gauge should be watched closely. If a working pressure of 500 pounds is desired and only 300 or 400 pounds pressure is indicated by the gauge, be prepared with the proper wrench to tighten the pressure adjusting nut on the pressure regulator. Continue turning down the adjusting nut until the pressure gauge gives a reading of 500 pounds and discontinue adjustment at that point.

The whole unit is now in working order and ready for the spraying materials to be added to the water in the filled tank. The materials are quickly poured in, and the mechanical agitator at once churns them into a uniform solution. The mixture is ready to be sent out through the main pipe line to the orchard.

Now open the valve in the large or main pipe line leading to the orchard. Upon doing so a momentary hissing rush of liquid may be heard inside of the pipe. Simultaneously, the pressure gauge will register a drop from 500 pounds almost or quite to zero. However, as the orchard pipe lines become more and more nearly filled with spray solution, pressure will again build up to the maximum of 500 pounds. Overflow of the solution back into the mixture tank will be resumed and continue in full volume until the spraymen in the orchard open their guns and begin coverage of trees. The volume of overflow back into the spray tank will then greatly decrease but not cease altogether when all nozzles in the orchard are discharging spray. The pressure of 500 pounds as shown by the pressure gauge will be maintained.

During the time that the contents of tank No. 1 are being pumped out and converted into spray in the orchard, the plant attendant promptly proceeds to fill tank No. 2 with water and to weigh or measure out and add the spraying materials; for the fresh tank of solution must be ready for delivery to the orchard at the moment the contents of tank No. 1 are nearly exhausted.

When only a few gallons of spray solution remain in the bottom of tank No. 1 and before the spray pump begins to draw air through the outlet, the valve near the bottom of tank No. 2 should be opened and the valve of No. 1 quickly closed. Also, overflow valve No. 1 should be quickly closed and No. 2 opened (at filling doors of spray tanks). Pumping from tank No. 2 begins immediately without loss of a single pound of pressure or an instant of time.

The two tanks are thus alternately refilled and mixed and spraying continued until quitting time at noon or night. It is advisable, however, that the tank of solution from which spraying is being done be finished at quitting time, and the spraying materials withheld from the tank of water that stands ready for use, until time for work to proceed after lunch or the following morning.

Where the orchards, as in the Dale View project, for the most part are situated at a considerably higher elevation than the spray plant, most of the spray solution contained in the main pipe system when spraying of the larger orchard areas is finished may be returned to the spray tank by gravity by opening the previously described valve in the tube connecting the orchard pipe line with the overflow pipe leading from the pressure regulator to the spray tank. The large, nearby valve in the main or orchard line is then closed. Then, by means of a secondary small or "pony" orchard pipe system independently installed near the homestead and the opening of another valve admitting the spray solution from the main orchard pipe line to this pipe system servicing only the grounds of the homestead, the surplus spraying solution returned from the main lines on higher ground may be utilized for spraying the trees nearby.

When the current period of spraying is completed, the pipe systems are thoroughly flushed with clear water, as described previously, and the entire system permitted to remain filled with water until the succeeding period of spraying.

SPRAY HOSE AND GUNS FOR USE IN STATIONARY SPRAYING

One-hundred-foot lengths of spray hose are used by the spraymen in the orchard. Manufacturers of spraying equipment recommend hose not less than $\frac{1}{2}$ inch in diameter of bore, for lines as long as 100 feet. By use of a hose 100 feet in length and of smaller diameter, they prove, by reference to scientifically prepared friction tables, the loss of pressure by friction of the spraying solution against the inner wall of the hose is far too great to warrant use of the smaller size. During the first few years in the Dale View stationary spraying project, these recommendations were fully observed. However, 100-foot lengths of liquid-filled, half-inch spray hose are heavy to handle in the orchard. Consequently, equal lengths of three-eighths inch spray hose of high quality were given thorough trial, simultaneously increasing the working pressure of the pump at the power plant to 600 pounds. The spraymen were much relieved by the lightening of their burdens. Spraying pressure in the orchard was wholly satisfactory. Hereafter, only three-eighths inch spray hose will be purchased.

Handling of 100-foot lengths of spray hose is rendered very much easier for the orchard spraymen in hillside orchards if spraying always is begun at the hilltop. By so doing the movement of the hose is always downhill rather than uphill. This means a very great saving of hard work by the gunmen—relief that usually is greatly appreciated. In preparation for each successive spraying the coils of hose are loaded into a light car or truck and taken to the hilltop starting point.

Short guns either of the large, single-nozzle, adjustable spray type or the two- or three-nozzle (smaller disk) fog-drive style are used with satisfaction in connection with the stationary spraying system. The single-nozzle, adjustable form of gun is admirable for use by the careful workman who will con-

tinuously adjust the volume of spray according to requirements of the upper and lower hemispheres of the trees. Some of the three-nozzle types are non-adjustable, producing at all times fine, soft, mist-like sprays and therefore are better suited to the inexperienced workman.

STATIONARY VERSUS PORTABLE SPRAYING OUTFITS ON STEEP OR ROUGH ORCHARD GROUND

As before stated, the spray pump used in the stationary spraying setup at the Dale View Test Orchards has a capacity of 20 gallons per minute at 500 pounds pressure for average working conditions. As a matter of fact, much greater pressure and capacity of this same unit are available should they be needed but remain under perfect control as reserve capabilities. However, a spray pump discharging 20 gallons per minute does not mean that, in actual spraying, the three lines of hose in the hands of as many careful spraymen will average 20 gallons of spray per minute, or 1200 gallons per hour, applied to the trees in the orchard. Working from the ground as they do, the spraymen obviously require time to disconnect their spray hose from the pipe line outlets and change to others from 100 to 120 feet distant, time to place themselves at the most strategic positions for attacking the successive blocks of trees to be sprayed from the new pivotal points, and time, even, for changing their positions for spraying large, individual trees. For the latter must be sprayed first from beneath their branches and then from outside positions and from every possible angle. During these unavoidable delays of longer or shorter duration in the continuity of spray application, the mechanical pressure regulator at the distant power plant must take care of the excess spray solution passing steadily through the pump at the rate of 20 gallons per minute.

Doubtless someone will remark that such loss of time in stationary spraying is sufficient to condemn the system as an impractical and wasteful one.

On the other hand, on orchard ground that is topographically comparable, use of even the most modern and excellent types of small, portable spraying outfits usually will involve loss of much more time than does the stationary type. For, as each tank of spray is emptied, the pumping mechanism must be stopped and the entire outfit [motor, pump, tank, and foundation (truck)] trundled by team or tractor some distance to be refilled and the spraying materials added.

On orchard ground as steep as that upon which the Dale View project is situated, the only type of portable power sprayer found that met the requirements was a low-hung, small outfit with a spray tank not exceeding 100 gallons in capacity. With such a sprayer, drawn by a necessarily heavy team of horses, 10 tanks or 1000 gallons of spray solution per 8-hour day constituted the maximum output, with eight tanks, or 800 gallons, as the average day's work.

Therefore, an excellent opportunity was and still continues to be afforded to make a fair comparison of the amount of work per day and cost of operation of two widely different types of spraying equipment used under practically the same difficult conditions insofar as very steep and rough ground is concerned.

**RELATIVE CAPACITY AND COST OF OPERATION OF THE TWO TYPES
OF SPRAYING EQUIPMENT ON THE SAME STEEP,
ROUGH ORCHARD AREA**

The relative requirements, capacity, and cost of operation of the two types of spraying outfits used on exactly the same steep, rough area of orchard ground briefly may be summarized in tabular form as follows:

	Stationary type of spray plant	Cost of operation	Portable type of sprayer	Cost of operation
Average number of gallons of spray applied per 8-hour day.....	5000	\$14.70	800	\$8.91
Average cost per 100 gallons		0.29		1.11
Data itemized:				
Men required to operate stationary plant: two at \$2.50 each; one at \$3.50; one at \$4.00.....	4	12.50		
Men required to operate portable outfit: one at \$3.50; one man and team at \$4.50....			2 and team	\$8.00
Gallons of gasoline used per day	10	1.90	4	0.76
Quarts of oil used per day	1	0.30	$\frac{1}{2}$	0.15
		\$14.70		\$8.91

Note: The above data indicate that the orchard foremen serving with both the stationary and portable outfits receive the same pay; namely, \$3.50 per day of 8 hours. Somewhat lower-priced help usually may be employed in stationary spraying with an experienced foreman. With the small, portable spraying outfit, only the foreman handles the single gun and hose used.

The operator of the stationary spraying machinery, who also does the mixing of sprays, necessarily has to be trained for such a position; hence, he should be allowed a somewhat higher rate of pay than the orchard foreman.

Cost of piping the orchard.—Distance from the power and mixing plant to the orchard, size and form of the orchard, and distance apart of the rows of trees all have a bearing on the length of the larger or main pipe that will be needed. However, within the boundaries of the orchard, best quality galvanized steel water pipe for the “mains” (1¼ inches in diameter), laterals (¾ inch in diameter), and pipe-fittings, the necessary high-pressure bronze gate valves, and high grade hose connections or “cutoffs” usually will total from \$20 to \$23 per acre of trees. The pipe lines complete, including all high-pressure fittings, amounted to just \$25 per acre for the 20-acre project at Dale View Orchards (\$500 for the 20 acres piped).

**COMPARATIVE COST OF PORTABLE AND STATIONARY
SPRAYING MACHINERY**

The relative costs of stationary and portable spraying machinery alone, exclusive of piping, hose, etc., necessary to distribution of sprays in the orchard, obviously are quite variable according to “make”, quality, size, and capacity of the two types of sprayers. However, using for comparison the same two outfits that have been under discussion (namely, the portable machine

that necessarily had to be small in size, weight, and capacity for steep ground conditions and the stationary equipment as described) the first cost of the latter was approximately double that of the small portable outfit, including the truck upon which it was mounted. As a matter of interest in this connection, it may be well to add that other high grade, much more expensive, portable spraying machines of larger size and greater pump and tank capacities were given trial; but these heavier, portable types of outfits simply could not be used on the steep orchard slopes.

On the other hand, where the orchard areas are but slightly rolling or nearly level, it is quite possible to use heavy, portable spraying equipment of great power and capacity. Under such conditions cost of the motor and pump of a stationary plant should not be far different from that of the motor and pump of like capacity for a portable outfit. Such motor and pump units, as a matter of fact, in many cases are interchangeable. True, the spray tank of the stationary setup, at least double the size of that of the larger type portable sprayer, is somewhat more expensive; but its advantage of much greater capacity far outweighs any conceivable objection to its greater cost.

A stationary spray plant eliminates the need of a heavy, expensive, wheeled truck such as that upon which a large portable outfit must be mounted. Nor does it require a team or tractor. It simply requires a level, solid foundation in some conveniently located building, where it will operate free from vibration and be protected at all times from inclement weather conditions. Thus installed, a stationary spraying plant that is of high quality at the outset and well cared for at all times should continue to give excellent service for a long period of years.

II. HOME MAKING OF LIQUID LIME-SULFUR

INTRODUCTION

Since its first use in Ohio about 25 years ago, many apple growers have come to regard commercial liquid lime-sulfur as the most potent and least expensive fungicide for prevention of apple scab. A relatively small number of orchardists have attempted to effect still further reduction in costs of spraying by devising simple equipment of various types for home production of necessary supplies of liquid lime-sulfur solution. The consistent adherence of this small group of growers to such practice is evidence that they have been satisfied with the operation of their boiling plants.

The interest among the fruit growers of Ohio seemed to justify the construction of an experimental boiling plant and storage for home-made concentrated liquid lime-sulfur, and these are here described.

THE BOILING PLANT

A small, compact, practical steam boiling outfit was installed at the Dale View Test Orchards, near Newark, Ohio, to test the practicability of home manufacture of liquid lime-sulfur. The equipment is housed in a small building erected for a workshop and incidentally to cover a large open cistern for storage of water for spraying. The circular cement wall of the cistern provides the foundation for the building. The setup as a whole is shown in Figure 1.

The several features of the small lime-sulfur factory are outlined in Figures 2 and 3. They consist of a vertical steam boiler (b and c), an elevated water heating tank (d), a cypress curved-bottom boiling vat (e), a large settling or clearing tank fitted with a straining device (f), and a cement, underground storage cistern (g) into which the lime-sulfur concentrate is drained from the clearing tank.

The natural conditions at Dale View were ideal for operation of the plant almost wholly by gravity. The lime-sulfur solution, from the time it is through boiling, flows naturally from the cooking vat through the straining device into the separate special storage cistern and from thence through an underground pipe to the stationary spraying plant located at a still lower level on the hillside. There was available a gravity water system afforded by a small storage cistern situated on the summit of an adjacent hill, the water being pumped to the cistern from a spring. Water pressure at the boiling plant stands constantly at 63 pounds.

THE STEAM BOILER

It may be stated that the steam boiler, although small in size (1½ horse power), generates ample steam for rapid boiling of the lime-sulfur mixture in 100-gallon batches. The steam pressure during the process of cooking ranges from 5 to 10 pounds, depending upon regulation by the steam valve directly above the boiling tank (e). With water pressure from the hilltop cistern standing constantly at 63 pounds and the steam pressure in the boiler at all times very much lower, the need for an injector for forcing the water into the boiler by means of steam pressure is eliminated. The desired level of water

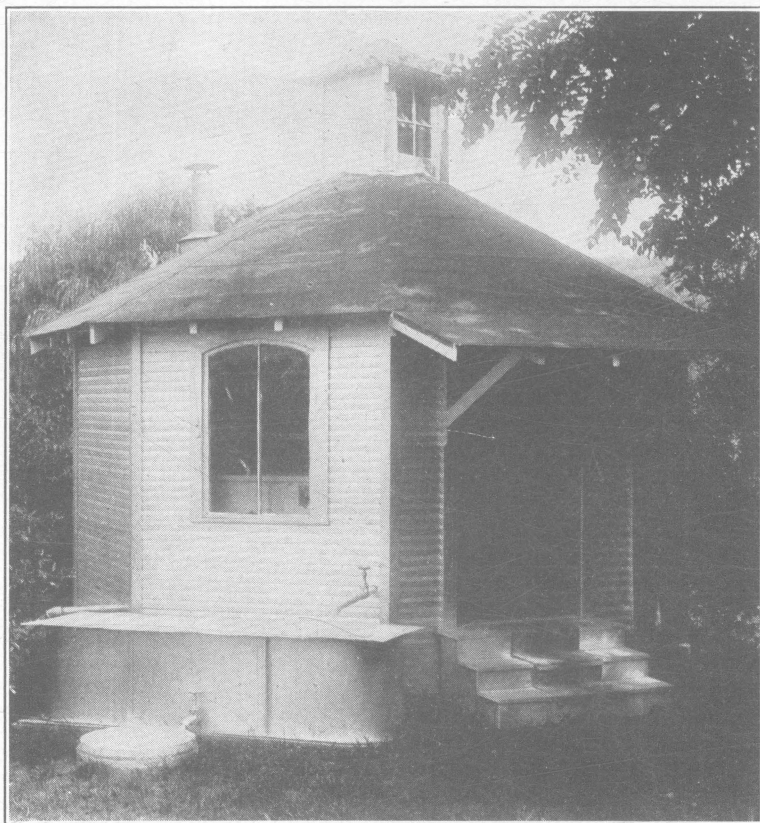


Fig. 1.—The small, compact, steam-operated liquid lime-sulfur boiling plant at the Dale View Orchards, central Ohio

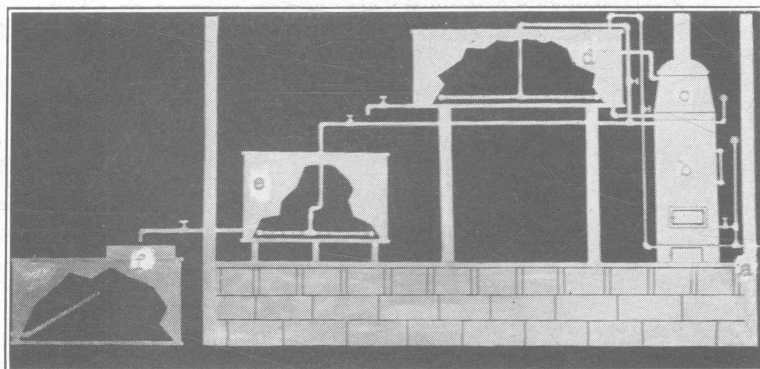


Fig. 2.—The steam boiling equipment

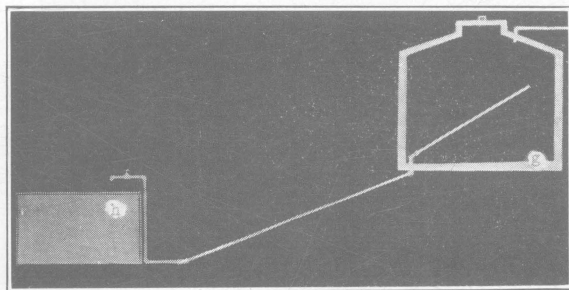


Fig. 3.—The underground lime-sulfur storage cistern and pipe line to spray plant

in the boiler, as indicated by the water gauge of the latter, is readily maintained by opening occasionally a small gate valve shown near (a) and just above the main water pipe entering the boiler room from the supply cistern.

WATER HEATING EQUIPMENT

Within a supplementary steel drum fitted to the top of the boiler, directly above the vertical flues, is a coil of 30 feet of $\frac{3}{4}$ -inch copper tubing. The projecting upper and lower terminals of the coil of tubing are connected by means of attached short sections of water pipe with the water heating tank (d). The heavy sheet steel coil housing is securely covered by the regular outlet or smokepipe fitting of the boiler.

The water heating tank (d) is installed at a somewhat higher level than the top of the boiler and is filled by means of an extension of the main water line from the cistern. The water is heated in two ways: first, by means of its circulation through the coil of copper tubing installed in the top of the steam boiler, and, second, by a supplementary, perforated pipe located near the bottom of the heating tank, connected with the main steam pipe leading from the boiler to the cooking vat, and controlled by a valve shown at the right of and close to the end of the heating tank.

Thus, by taking advantage of the intense heat escaping from the firebox of the boiler and passing upward through the vertical flues (heat that otherwise would be wasted) and likewise by diverting the steam pressure from the cooking vat to the water heating tank during the process of emptying and refilling the former, there is at all times an abundant supply of scalding hot and often boiling water.

THE BOILING VAT

A round-bottom cypress sprayer tank of one-third greater capacity than the maximum quantity of solution to be boiled at a time affords a serviceable and convenient cooking vat.

The process of cooking the lime and sulfur mixture in the boiling tank (e) is effected by live steam issuing from a perforated pipe lying near the bottom of the tank. The apertures in the pipe are about three-sixteenths of an inch in diameter, 6 inches apart, and are drilled at various angles in order to send the jets of steam into the mixture in different directions. It may be seen in the

illustration that the vertical section of steam pipe entering the cooking vat (e) has an offset or double bend at about two-thirds the depth of the tank. This offset is a flexible joint in the pipe formed by two identical pipe fittings, commonly called "street ells", and permits the perforated steam pipe to be folded up out of the way of mixing the sulfur and slaking the lime.

The outlet pipe from the cooking vat, with valve through which the finished lime-sulfur solution is conveyed to the straining device, is shown extending to the left from near the bottom of the boiling vat. The opening inside of the vat leading into the outlet pipe is protected by a metal-capped plug or shield attached to the lower end of a 2-foot section of spring steel, the upper end being fastened with a single screw near the upper inside edge of the tank end. The spring stopping device with ample tension to hold it securely in place prevents clogging of the outlet pipe during the mixing, slaking, and boiling operations. It is easily removed or swung to one side out of the way while emptying the tank. An opening at the right end of the cooking vat, in the bottom, is fitted with a 2-inch pipe and easily removable plug. Through this larger outlet the coarse residue or sludge may be removed from the bottom of the vat after each boiling. This outlet device is not shown in the illustration.

THE UNDERGROUND STORAGE CISTERN

The plan of the underground lime-sulfur cistern is shown in Figure 3 (g), with the inlet pipe at the top (right) and the hinged or adjustable outlet pipe at the bottom (left). Here again the combination of two "street ells" forms the flexible union. The outlet pipe, as indicated, leads underground to the stationary spraying plant farther down the hillside and terminates with elbow and globe valve fittings above the 1000-gallon spray tank at a convenient height for measuring the liquid when mixing the spraying solution.

COST OF EQUIPMENT FOR BOILING LIME-SULFUR

Exclusive of the small new building in which it is installed, this lime-sulfur boiling outfit complete cost \$263.82. This expenditure for equipment and installation may be classified as follows:

1½ h. p., slightly used steam boiler with fixtures	\$60.90
Tanks and tank fixtures	66.46
Pipe and pipe fittings, including valves and plumbing	83.19
30-barrel cement cistern for storage of lime-sulfur	26.90
Miscellaneous equipment and fittings	26.37
Total	<u>\$263.82</u>

Following several tests conducted on an experimental basis, in which different forms and brands of both lime and sulfur were used, the large receiving or clearing tank (f) was eliminated as an unnecessary feature, inasmuch as the storage cistern is so arranged as to accomplish satisfactorily the same function. Use of a rotary, barrel-form, sulfur paste mixing device (not shown in the illustration) also was discontinued after adequate trials, as it was found that the sulfur paste could be mixed more easily and far more quickly in the cooking vat. These eliminations of superfluous articles of equipment reduced the cost of the actual working outfit to \$241.97.

CAPACITY OF THE FACTORY

The capacity of this small steam lime-sulfur boiling plant was found to be 400 gallons of concentrate per each 8-hour day of operation.

There are, as a matter of course, many types of equipment for making liquid lime-sulfur at home that are both simple and inexpensive. A number of different types of cooking plants are described in Farmers' Bulletin No. 1285 of the United States Department of Agriculture.¹ Orchard owners interested in building their own plants will find this bulletin helpful.

*A DESIRABLE FORMULA FOR MAKING LIQUID
LIME-SULFUR*

It has been found possible to produce in the lime-sulfur plant just described a liquid concentrate of the so-termed "standard", or 32 to 33 degree Baumé test. However, the proportions of sulfur and lime required to yield this high-testing product compose a mass of solid materials too bulky and heavy to handle readily without power equipment, for 320 pounds of sulfur and 160 pounds of stone lime (or a total of 480 pounds of dry mineral matter) are required to make 100 gallons of liquid lime-sulfur testing 32 to 33 degrees. With hydrated lime instead of stone lime, 33 per cent more by weight is required, making a total of 532 pounds of solid materials from which to obtain 100 gallons of finished lime-sulfur solution. There is, moreover, a relatively greater waste of materials in attempting to utilize this heavy formula.

The formula designated as No. 2 (advised by the United States Department of Agriculture) for home manufacture of liquid lime-sulfur is as follows:

Stone lime	100 pounds
Sulfur	200 pounds
Water to make	100 gallons

This lighter formula is far more readily handled with home equipment and yields a concentrate testing 28 to 29 degrees Baumé.

LIME THAT SHOULD BE USED

Only high calcium lime should be used in making liquid lime-sulfur. By analysis it should contain at least 90 per cent of calcium oxide and not more than 5 per cent of magnesium oxide, as presence of the latter in the lime will result in large proportions of insoluble matter, termed waste or sludge. It is now possible to purchase lump lime very high in content of calcium, packed in airtight steel drums. Thus packed, the hard lumps are preserved in fine condition almost indefinitely. Freshly hydrated lime may be used successfully in making liquid lime-sulfur, but high quality, unslaked lump lime is to be preferred. The slaking process also generates intense heat which need not be wasted.

SULFUR

Common flour of sulfur, if fresh and free from lumps, is suitable for making liquid lime-sulfur. Sulfur becomes more or less solidified if allowed to stand in bags for a considerable period of time. In such cases it should be shaken or rubbed through a fine screen in order to reduce the material to the

¹Siegler, E. H. and A. M. Daniels. 1922. Lime-sulfur concentrate; preparation, uses and designs for plant. U. S. D. A. Farmers' Bull. 1285.

finest possible condition. Even tiny lumps of sulfur, such as may be sifted or forced through a wire screen of from four to six meshes to the inch, are very likely to become coated with lime and pass entirely through the boiling process without becoming dissolved or combined with the lime. These lumps appear in the so-called sludge as small hard pebbles of pure sulfur. Granulated sulfur doubtless is the best form for making the liquid solution. This form of sulfur remains in good condition much longer than the refined material.

SLAKING THE LIME

Two methods of slaking the lime were tried. The first method consisted of slaking the stone lime in a generous quantity of very hot water in the boiling vat and then adding the thin sulfur paste after the slaking process was completed. Several objections to this order of procedure developed and the whole plan of slaking and mixing was reversed, with excellent results. The revised plan is as follows: The sulfur is first reduced to a thin smooth paste in the cooking vat by generous use of boiling water direct from the water heating tank and stirring briskly. Next, enough more boiling water is added to fill the vat about half full. Into this hot sulfur paste the lime is poured and stirring from the bottom begun at once. The lime begins slaking very quickly and proceeds rapidly, but the evidences of the process are so muffled and lessened by the heavy mass of sulfur paste that they are hardly noticeable. When the lime has finished slaking, the smoothly combined mass usually is quietly but freely boiling. More boiling water is added if necessary to raise the level of the mixture to the 100-gallon mark on the inner surface of the boiling tank. After this, it is only necessary to turn on the live steam from the boiler to continue the boiling.

It is at this particular stage in the manufacture of liquid lime-sulfur by use of home equipment that high quality unslaked lump lime possesses an outstanding advantage over equally high grade hydrated lime. The slaking of lump lime as just described generates great heat and brings the newly combined materials without loss of time to the boiling point. On the other hand, the addition of hydrated lime, in the required 33 per cent greater amount by weight, cold to the hot sulfur paste so greatly lowers the temperature of the latter that much time and steam are required to raise the combined mass to the boiling point.

AGITATION DURING THE BOILING PERIOD

It is advisable to stir the lime-sulfur mixture constantly while it is cooking, especially during the first half of the boiling period. A strong wooden paddle about 4 feet in length is used for this purpose. During the latter half of the period of cooking the jets of live steam briskly issuing from the perforated pipe at the bottom of the vat take care of agitation. During the cooking period if the level of the boiling solution should become even slightly lowered by evaporation, the required amount of boiling water should be added to restore the level to the 100-gallon mark. Little if any reduction of the volume by evaporation is likely to occur however when cooking with live steam.

PROPER PERIOD OF ACTIVE BOILING

The mixture of lime and sulfur should be actively and uninterruptedly boiled until the materials have gone into perfect solution and combination. As the cooking proceeds the color of the solution gradually becomes darker until,

near the finish, it appears almost black in the boiling vat. The required time for actual boiling is 50 minutes. A mistake that the beginner is likely to make, however, in timing the period of boiling is to begin counting time before actual boiling begins. If the mixture is not quite up to the boiling point when the steam is turned on, the contents of the tank will bubble freely for a short time before true boiling begins. A thermometer scaled for high temperatures may be a help at the outset, but very short experience will render such an instrument unnecessary.

STRAINING THE FINISHED SOLUTION

As soon as the solution is done boiling it should be run off from the boiling vat through a very fine brass wire strainer (30 to 50 mesh). From the strainer it may go directly into wooden barrels, steel drums, clearing tank, or cement storage cistern. Invariably, there is a very fine greenish sediment (not sludge) present in newly made lime-sulfur solution. This extremely fine matter readily passes through the smallest mesh wire screen that is practical for use for the purpose of straining out residue or waste from the finished concentrate. It is not detrimental for home use in spraying. The sediment can be eliminated only by filtering or by permitting the newly made concentrate to stand several hours or over night in a large settling or clearing tank and then running the clear liquid off through an adjustable outlet pipe.

CRYSTALLIZATION OF NEWLY MADE LIME-SULFUR

Exposure to the air of newly made lime-sulfur very quickly results in formation of tiny crystals resembling short splinters of white wood. These minute crystals will form on the surface of the concentrate in the clearing tank if the contents, even though covered, are allowed to stand over night. As the tiny particles begin to develop they have a tendency to settle on the bottom of the tank or to adhere to the inner surfaces of its sides and ends. Hence, it is well to store the freshly made solution in airtight, well filled, tightly stopped casks as soon as possible after boiling. Little or no crystallization will occur in such containers. Partly filled casks containing considerable volumes of air will permit crystallization to continue.

SEALING THE CONTENTS OF THE STORAGE CISTERN

When the material is run from the straining device directly into an underground cistern, a gallon or two of inexpensive motor oil added immediately will form an airtight film or "seal" over the surface of the lime-sulfur solution, affording perfect and lasting protection from crystallization to the contents of the cistern. No matter whether the concentrate is withdrawn for spraying by means of a pump at the ground or platform level or through a pipe leading underground to spraying equipment, the covering of oil will give no trouble so long as the inner terminal of the suction or outlet pipe is below the level of the protective film. As additional batches of newly boiled lime-sulfur are run into the cistern no more oil need be added, for the film will rise as the volume of lime-sulfur deepens and spread to form an airtight seal over the entire surface.

RESIDUE OR SLUDGE

More or less coarse sediment will remain in the bottom of the boiling tank after the liquid lime-sulfur has been run off. This coarse matter may be removed by means of a small scoop or, better still, washed through an ample

outlet fixture provided in the bottom of the tank and controlled by a gate valve. The boiling tank should be well cleaned of all residue after each successive period of cooking.

The kind of lime used makes a very great difference in the amount of sludge remaining after running off the liquid lime-sulfur at the finish of each boiling. As little as one-fourth gallon of such waste matter from each 100-gallon lot of freshly made concentrate has been obtained in the tests in which high calcium lime (either lump or hydrated) was used. On the other hand, as high as 6 gallons of coarse residue have been left in the bottom of the cooking vat from 100-gallon batches of liquid lime-sulfur made by the use of lime which, while claimed to be a high calcium product, actually contained a high proportion of magnesium oxide and other coarse materials.

TESTING THE NEWLY MADE SOLUTION

A special hydrometer is necessary for testing newly manufactured lime-sulfur. Some of these instruments are marked with a Baumé scale, others register specific gravity, and still others are scaled for both Baumé and specific gravity readings. The Baumé scale is used almost exclusively in determining the density and the advisable degree of dilution for its use in spraying. Newly boiled liquid lime-sulfur should not be tested until it has cooled to a temperature of about 60 degrees Fahrenheit. While still warm it will test considerably lower than after it has cooled. As previously stated, the preferable formula of 100-200 proportions, by weight, of lime and sulfur, respectively, usually will yield a concentrate testing, at 60 degrees, 28 to 29 degrees Baumé. For all practical purposes in spraying for apple scab such home-made concentrate is fully as desirable and efficient, when properly diluted, as the commercially prepared product.

WILL IT PAY TO MAKE LIME-SULFUR AT HOME?

One of the first questions that is likely to be asked by the owner of an orchard when he first becomes interested in the subject of home manufacture of liquid lime-sulfur is: "Will it pay me to invest in special equipment for this purpose?" To the majority of such inquirers the reply is, "No". In sections of our State where orchards are small and widely separated, as in the leading agricultural communities, it will not pay. In large apple growing communities where it is entirely feasible for the growers to pool their requirements and purchase commercial liquid lime-sulfur at the lowest possible wholesale price, in tank-car lots, it will not pay to attempt making the concentrated lime-sulfur at home or even in a community plant.

On the other hand, in the case of isolated orchards of considerable size, well equipped small private plants for production of liquid lime-sulfur may prove profitable. Again, in communities in which several relatively small commercial orchards are located and where lime-sulfur instead of being purchased in car lots at wholesale prices has to be purchased at retail prices in casks or drums, a small community boiling plant may prove serviceable.

COMPARATIVE COSTS

Including costs of raw materials and labor, a small lime-sulfur factory such as has been described in this bulletin effects an average saving of from \$25 to \$30 per day for each 8-hour day of its active operation in the difference in cost of equal gallonage between the home-made and the commercially manufactured liquid concentrate, at the recently prevailing retail prices for the latter by the barrel or drum of 50-gallon capacity.